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ABSTRACT

The ultimate goal of the science of artificial intelligence (AI) is to establish programs that will use algorithmic computer techniques to imitate the heuristic thought processes of humans. Most AI programs, especially expert systems, organize their knowledge into three specific areas: data storage, a rule set, and a control structure. Limitations restricting the development of AI include the use of limiting heuristics, data processing speed, organization of memory, AI accuracy, and sensitivity (underdeveloped recognition and processing of data subtleties). AI's most immediate future impact will be in the analysis phase of the Training Technology System, a five-phase model of the training process. The two main components of this phase in which expert systems could be applied in the future are the processes of training needs assessment and work behavior analysis. (YLB)

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ARTIFICIAL INTELLIGENCE: AN ANALYSIS OF THE TECHNOLOGY FOR TRAINING

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ARTIFICIAL INTELLIGENCE:

AN ANALYSIS OF THE TECHNOLOGY FOR TRAINING.

INTRODUCTION

The term artificial intelligence (AI) is becoming increasingly prominent in the training literature. Not unlike other developing technologies, the concept of AI tends to intimidate any one who is not familiar with the true capabilities and limitations of the science. Natural language processing, computer vision, and expert-system development are considered to be the three main facets of AI. Futurists and applications theorists have conceptualized many environments in which the computer is the ultimate learner, thinker, and decision maker. In reality many obstacles must be overcome before the computer will pose a threat to our major roles at home or in the workplace. This paper will define current AI, and will describe its components, the limitations restricting its development, and possible future applications in training.

FINDING AN ACCEPTED DEFINITION

Because of AI's various forms of development and applications, it is difficult to find a widely accepted definition for the term itself. Dehn and Schank (1985) explain, "Views as to what constitutes an intelligent program have changed considerably during the last two or three decades. Many programs that were once

considered intelligent or almost intelligent are no longer so regarded" (p.353). Hurzweil (1985) states that " Experts still debate about what constitutes an intelligent machine and they still disagree about what constitutes the field of study since John McCarthy gave it that name at a Dartmouth conference in 1956" (p.258). Much of the difficulty in defining AI seems to stem from the wide variety of definitions for the word "intelligence." The concept of intelligence continues to be debated among a large group of cognitive psychologists (Sternberg & Salter, 1985). Without a set criterion by which to define human intelligence, AI researchers have had difficulty producing anything more than a generic definition with resulting communication problems. The most widely accepted definition is that of AI researcher Marvin Minsky (1980) who states that "...artificial intelligence is the science of making machines do things that people need intelligence to do" (p.6). The general nature of this definition leaves much to the interpretation of the reader. According to this statement, a five-dollar pocket calculator could be considered an example of this science. Wyer (1984) elaborated upon this definition by explaining that "... the object is not to create a machine that can think, but rather to use machines to model thinking" (p.185). This perception of AI is necessary when considering the development of programs. The ultimate goal of the science is to establish programs that will use algorithmic computer techniques to imitate the heuristic thought processes of humans (Dehn & Schank, 1985).

Components of an AI program

In order to logically process, store, and retrieve data intelligently, most AI programs, especially expert systems, organize their knowledge into three specific areas. These areas include (1) data storage, (2) a rule set, and (3) a control structure. A basic understanding of the functions of each of these areas is needed before exploring the limitations currently faced in AI development.

The data portion of an expert system is much like that of other computer programs. It consists of all data being input and processed as well as any rules specifying the direction of the desired result.

The rule set is the most powerful portion of the system because it contains a virtual storehouse of general and specific rules that can be applied to the data being processed. Each of the rules in the set acts as a decision maker by comparing the data being processed to a widely accepted rule and deciding its fitness. The results of these rules may be as simple as a yes or no answer or as complex as a problem diagnosis. In many cases, these rules are linked so that once a decision is made, the resulting data is automatically transferred to another related rule. This large base of rules is considered to be the knowledge of the system (Maxim & Yaghmai, 1984).

The control structure or inference processor is the key element of an expert system, integrating the data and rules

together in an organized fashion according to the needs of the particular problem. This control structure could be defined as a library of approaches or strategies designating which rules should be applied and at what point (Kinnucan, 1984).

When all three of these areas are integrated properly, the resulting system is able to accept specific data pertaining to a problem, identify a pattern or relationship among the data (inference), and select the specific rules or rule sets to be implemented in order to arrive at a conclusion. During this series of steps, an incredible number of various possibilities are analyzed before completing the transaction. This point should be kept in mind as we discuss the current heuristic, speed, accuracy, and application limitations of this science.

AI LIMITATIONS

Use of Limiting Heuristics

Computers use algorithms to solve problems; humans use heuristics. An algorithm is a finite set of rules that lead to the correct result in a prescribed amount of time after each possibility has been investigated (Kuth, 1983). Dehn and Schank describe heuristics as "...a finite set of rules that give the sequence of operations for solving a specific type of problem... they do not guarantee that they will always lead to a correct answer" (p.358). Heuristics serve as assumptions or shortcuts in human thought which drastically reduce the number of possible

solutions when considering a given situation. Algorithmic programs, however, must consider every possible solution to a problem, unless some type of heuristic guidance is provided. Without the development of limiting heuristics, AI programs are very susceptible to an exponential explosion of possibilities in which their processing ability is reduced dramatically (Maxim & Yaghmai, 1984). In order to eliminate such problems in computing, AI personnel must develop heuristic limitations within programs to imitate the simple assumptions that human make naturally.

Speed

A second problem restricting current AI researchers is data processing speed. This program limitation is inherent due to many factors, the prominent ones being serial processing, organization of knowledge, and limiting heuristics.

Most of the languages currently being used in the development of AI are serial processing languages. This trend appears to be one of the greatest obstacles restricting the high-speed processing of problem-solving data since it only allows the computer to perform one task at a time (Kurzweil, 1985). Conversely, the human mind is capable of performing various tasks simultaneously in a process referred to as parallel processing. This highly efficient method of processing not only allows our minds to solve complex problems in a minimal amount of time, but it also permits us to compare data during the process (Longuet-Higgins, 1982). Although researchers have experimented with a few pseudo parallel processing

languages, most popular AI languages, such as LISP and LOGO, continue to be restricted by serial processing.

Organization of Memory

Another factor restricting the efficiency of AI programs involves the organization of memory (control structure, rule sets, and data). When constructing and maintaining large volumes of rules and data, the amount of information can quickly become overwhelming and misguided if it is not stored in an organized, controlled manner (Dehn & Schank, 1985). This organizational problem tends to be minimized when the rules or knowledge programed into the system are limited to one specific area. Once the system is expanded to receive the inputs from more than one knowledge source (human expert) or to include another area of expertise, organization becomes much more difficult. Maxim & Yaghmai (1984) state that " Part of the problem is the inability to maintain consistency among overlapping items in the knowledge base (rule set)" (p.302). Because of this problem, AI systems require editing whenever new knowledge is being input to assure that similar or contradictory rules are not developed which would lead to misguided decision making.

AI Accuracy

Even with controlled maintenance of the rule set, current AI systems still can not promise continuous accuracy. Human experts will continue to out-perform the machine experts until the knowledge bases become highly developed and refined. Maxim &

Yaghmai (1984) explain that current AI knowledge bases "...offer little guidance about the appropriateness of new problems or the boundaries of their own expertise, and so even the best of them come up with wrong answers" (p.302). We must continue to depend upon the expertise of the AI experts to maintain and expand the working capabilities of these systems and assure a high degree of accuracy in their results.

Sensitivity

One of the least developed areas of AI functioning is in the recognition and processing of data subtleties that may be obvious to most humans. As Wyer (1984) explained, "Even so simple a task as we perform every day--distinguish one person's face from another--becomes a programming nightmare" (p.186). The brain-body system has the unique ability to automatically recognize or ignore even the subtlest of differences in such areas as emphasis, importance, and expression that even the most intelligent computer programs can not begin to recognize (Longuet- Higgins, 1982). Because the subtleties have a direct effect upon the context in which the information is processed, recognition of these differences is essential to AI in the areas of natural language processing and computer vision, Highly complex rules pertaining to this "invisible data" must be developed if these programs are to imitate the accurate data recognition of the human mind.

AI's FUTURE ROLE IN TRAINING

Training is one field that should be able to apply as AI develops and matures. AI methods theoretically lend themselves to training since accurate, effective training depends upon expert knowledge in all facets of organizational operation, including assessing needs, analyzing work behavior, design of training, instructional delivery, and evaluation of training programs. Expert systems, when developed will become a welcome tool of the training profession. Training departments in particular should be able to harness AI technology to build expert data systems for many aspects of their training processes.

The Training Technology System (Swanson & Sisson, 1985) serves as a good process model to illustrate the possible areas of AI integration. The system describes five phases to the training process including analysis, design, development, implementation, and control. Although it reasonable to think that AI could ultimately be integrated within all of these areas, its most immediate future impact will be in the analysis phase of the model. The two main components of this phase in which expert systems could be applied in the future are the processes of (1) needs assessment and (2) work behavior analysis. This hypothesis is based on the the belief that the information systems presently being developed within many organizations could be incorporated within these expert systems.

AI In Training Needs Assessment

As companies become computer integrated, the amount of available data regarding product specifications, production, sales, and evaluation expands at an incredible rate. These growing data bases contain much of the information trainers presently search out to assess the training needs of the organization. Currently the main problem with this process is a lack of data organization, the inability to quickly locate and access specifically what is needed. AI system technology will allow trainers to expedite this type of procedure. To begin this needs assessment process, functional data from the many organizational divisions and/or functions would be input into an expert system shell program. A shell is program lacking the data and rule set. Using a shell program and an organization's database, trainers could construct intelligent systems capable of isolating various deficiencies within a companies operations. Once a rule set is input and tested, the shell program becomes an expert system capable of pinpointing organizational performance needs (see Figure 1). The promise of AI is that trainers will be able to quickly sift through extensive amounts of data and locate the symptoms of areas in which training could improve organizational performance. Once a list of the problem areas that could be addressed by training is generated, the trainer would then be able to prioritize the needs according to the present state of the organization and select those that should be addressed immediately.

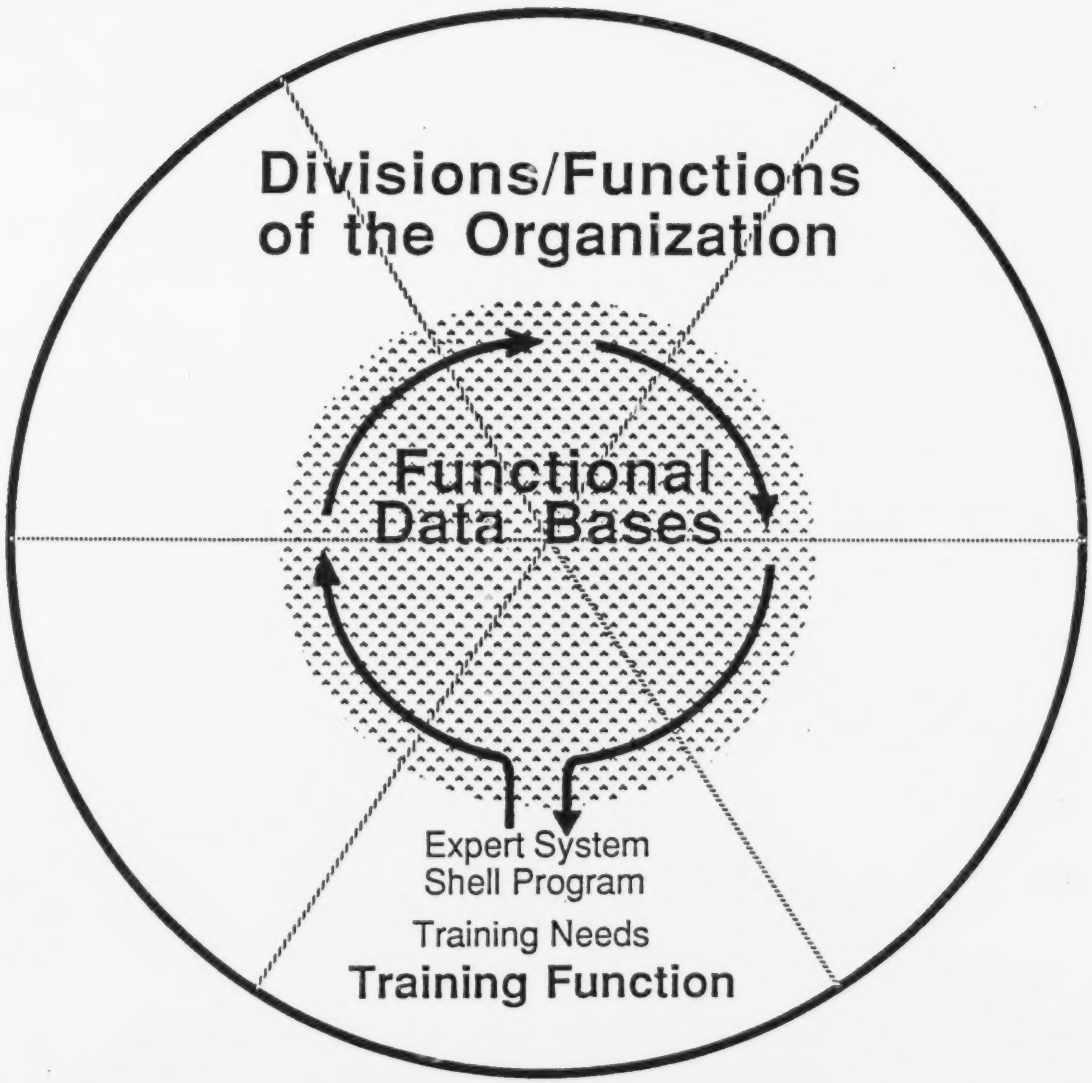

Figure 1. AI Shell Program for Determining Training Needs.

In Work Behavior Analysis

Once a specific training need has been isolated, the trainer begins to analyze the work behavior related to the need. This process includes an analysis of work procedures, processes and troubleshooting, and related subject matter required in the workplace (Swanson & Gradous, 1986). During this information-gathering period, trainers depend a great deal on human experts to describe all details attributable to the optimal performance of work tasks. AI programs could prove to be very effective in training applications which require a fusion of many different information sources. In organizations that are partially or fully computer integrated, this analysis process would involve the extraction of all database information related to the need being addressed. In those that are not, a highly detailed procedure and troubleshooting analysis, or subject matter analysis must be completed to collect the necessary data. This data could then serve as input to another expert system designed to simulate all related work behaviors. Related subject matter in the form of product and performance requirements from both internal and external sources could also be input at this time to enhance the programs rule set (see Figure 2). Once all available data has been input and carefully checked by a human expert, the program itself becomes the expert. This expert system would then allow the trainer to carefully analyze and document every detail involved in a specific work task.

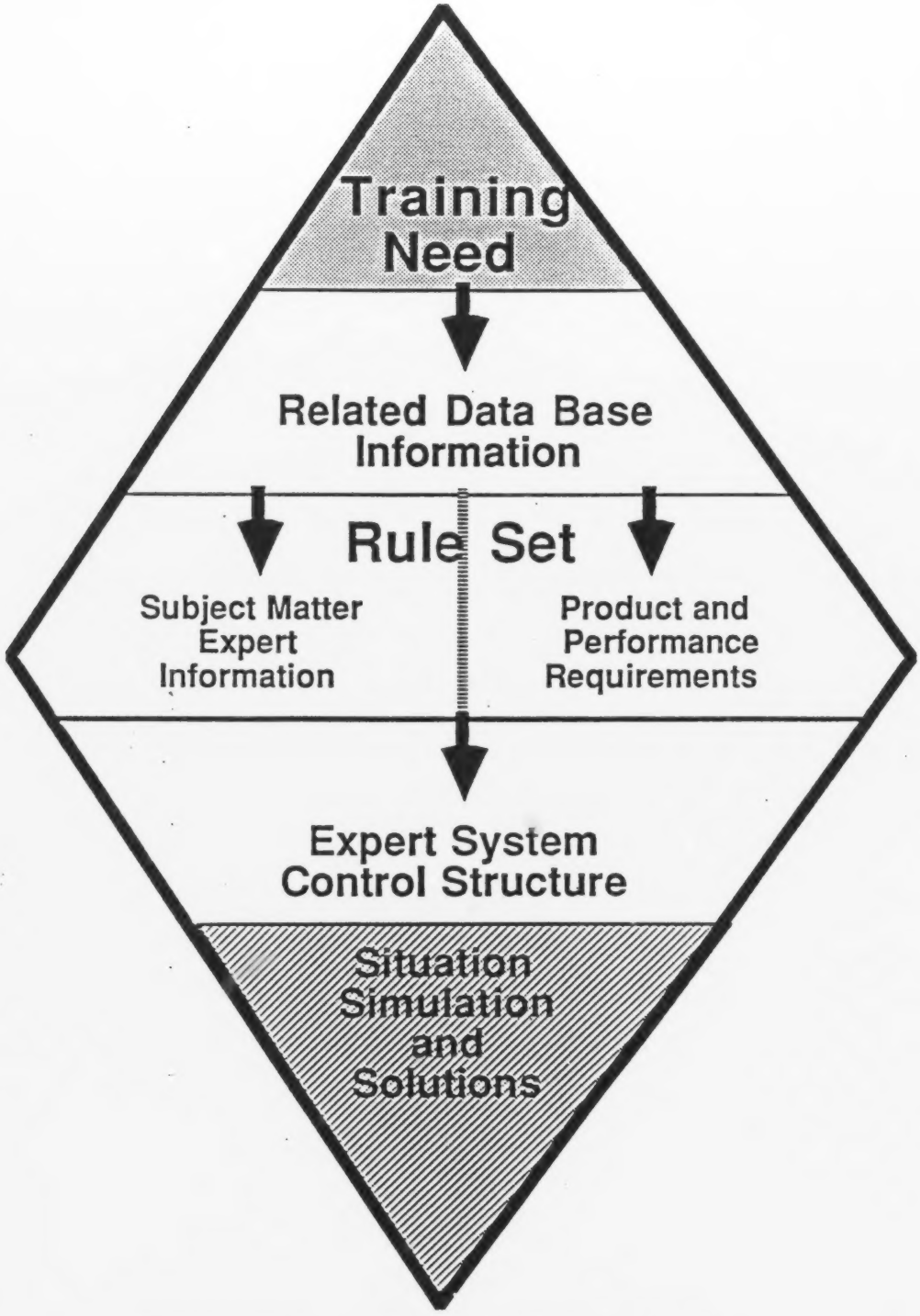

Figure 2. Intelligent analysis of work behavioir.

Once developed and checked, the expert systems will serve as permanent, reliable resources, that could be updated at any time to include future changes. They can simulate and predict process results due to deficiencies as well as recommend possible solutions in complex problem situations.

CONCLUSION

When considering all of the time consuming limitations that face AI researchers, it becomes more and more obvious how much of the science remains underdeveloped. Some restrictions, such as the lack of parallel processing languages, can be eliminated with the development of more efficient software. Other obstacles, such as limiting heuristics, accuracy and sensitivity have no simple answers. Only through the continuous research, maintenance, and updating of AI programs' rule and knowledge bases can these deficiencies be controlled. Currently, AI programs are not capable of performing these maintenance functions themselves and must remain dependent upon the "intelligent" human being to make these adjustments.

Although potential applications of this new science face many obstacles, there are a few professional fields, such as training, that already have access to some of the conceptual components required for expert system development. The future promises to offer a wide variety of new programming languages and shells for both general and specific applications. As trainers we should be

aware of these possibilities and strive to build and refine databases that serve us today and that could someday support these powerful, time-saving systems. By focusing on AI's abilities, recognizing its weaknesses, and keeping up on AI technology we will begin to prepare ourselves for its future role in the training profession.

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